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FUZZY CONTROLLER BASED MULTI-LEVEL UPQC USING DQ0 TRANSFORMATION TO IMPROVE POWER QUALITY IN DISTRIBUTION SYSTEM

S. Satthiyaraj[1] and S. Sankar[2]
[1]EEE St.Peter's University Chennai, India
[2]EEE Panimalar Institute of Technology, Chennai, India
E-Mail: Satthiya@gmail.com

ABSTRACT

The power quality becomes a very important issue due to rapid growth in use of loads. The recent developments in power electronic equipments ensure the safety and reliability. The power quality is nothing a sinusoidal voltage and currents waveforms exactly in phase. If there are any mismatches in voltage or current then there exists a problem on power quality. The problem of power qualities are voltage swell, sag, interruptions, harmonics and transients etc. This paper proposes to improve power quality in source side of distribution system using unified power quality conditioner (UPQC) by analyzing the cascaded multilevel inverter (MLI). UPQC is nothing a combination of series and shunt active power filters to compensate power quality problems. The Sine PWM switching scheme is used for better performance of MLI. The control methods of UPQC are derived from DQ0 transformation. To stabilize DC link voltage and balance the active power between series and shunt inverters the fuzzy logic controller is used. The regulation of source voltage in the distribution system using multilevel UPQC under non-linear load condition is analyzed. The operation of FUZZY controller for UPQC is done through MATLAB SIMULATION software.

Keywords: unified power quality conditioner; multilevel inverter; sinusoidal pulse width modulation.

INTRODUCTION

Power Quality (PQ) has become an important issue to electricity consumers at all levels of usage. The PQ issue is defined as any power problem in voltage, current, or frequency variations that results in failure or mis operation of customer premises. The advancement of power electronic based equipment has a significant impact on quality of electric power supply. The switch mode power supplies (SMPS), dimmers, current regulator, frequency converters, low power consumption lamps, arc welding etc.

The operation of this equipment generates harmonics and thus, pollutes the modern distribution system. The growing interest in the utilization of renewable energy resources for electric power generation is making the electric power distribution network more susceptible to power quality problems. In such conditions both electric utilities and end users of electric power are increasingly concerned about the quality of electric power. Many efforts have been taken by utilities to fulfil consumer satisfaction, most of the consumers require a higher level of power quality than the level provided by modern electric networks. It shows that some action must be taken so that higher levels of Power Quality can be obtained.

FACTS technologies offer competitive solutions to today's power systems in terms of increased power flow, ensuring continuous control over the voltage, improves system damping, increasing stability etc.

FACTS technology consists of high power electronics based equipment with its real-time operating control. There are two types of FACTS controllers based on different technical approaches, both resulting in controllers able to solve transmission problems.

UNIFIED POWER QUALITY CONDITIONER

UPQC is a combination of series and shunt compensating devices connected through a capacitor which is used for energy storing device. Active filter have been proposed as efficient tools for power quality improvement. Active power filters can be classified as series or shunt according to their system configuration.

The series APF generally takes care of the voltage based distortions, while shunt APF mitigates current based distortions.

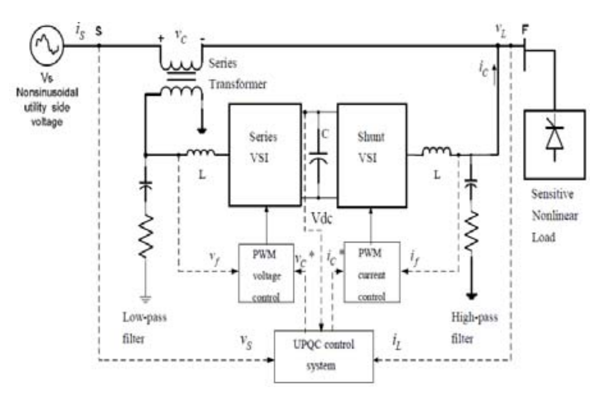

Figure-1. Detailed configuration of UPQC.

UPQC mitigates the voltage and current based distortion simultaneously as well as independently.

MAJOR POWER QUALITY PROBLEMS

Depending on the fault location and the system conditions, the fault cause temporary voltage drops, voltage rises, or a complete loss of voltage. The time duration of short voltage variations is less than 1min. These variations are formed by fault conditions.

Voltage Sag

Voltage sag also called voltage dip. It is a brief decrease in the line voltage of 10 to 90 percent of the nominal line-voltage. The duration of sag is 0.5 cycle to 1 min. Common sources that contribute to voltage sags are the starting of large induction motors and utility faults.

Voltage Swell

A swell is defined as increase in the rms line-voltage of 1.1 to 1.8 percent of the nominal line-voltage for duration of 0.5 cycle to 1 min. Swells may be caused by switching off a large load or energizing a large capacitor bank.

Interruption

An interruption is a reduction in line-voltage or current to less than 0.1 pu of the nominal, for a period of time not exceeding 1 min. Interruptions may occur due to power system faults, system equipment failures and control malfunctions.

ACTIVE FILTERS

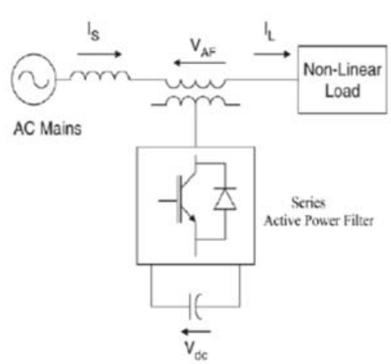

Figure-2. Series active filter.

It can acts as a controllable voltage source. It injects a voltage through injection transformer.

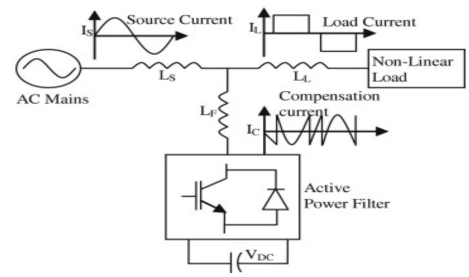

Figure-3. Shunt active filter.

Shunt active filter can compensate for current harmonics and perform power factor correction

SINSOIDAL PULSE WIDTH MODULATION

Carrier Shifted Sinsoidal Pulse Width Modulation Scheme

It is the best switching scheme for VSI. In this method all the pulses are varied with respect to sinusoidal function to give better output of the inverter. The output voltage is depends upon the value of modulation. The triangular carrier waveforms are shifted by some angle the basic generation of pulses by intersecting the sine wave with triangular carrier as shown in Figure.

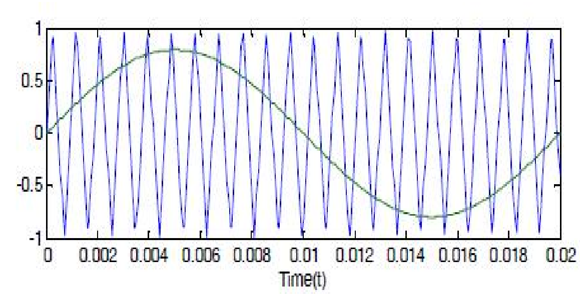

Figure-4. The SPWM switching scheme.

If the carrier signal is low then the output is low and if the carrier goes high the output will high.

Design of Controllers using dq0 transformation

The series controller mitigates the voltage related problems the compensation of series APF is the difference between source voltage and load voltage (V_{se}=V_{source}–V_{load}).

The design of controller is based on dq0 algorithm. First the source and load voltages (three variables) is converted into V_{dq}(two variables) by using park transformation see equation (1, 2). The second order low pass filter (LPF) is used. The sequence of designing controller is as follows.

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$$V_{sabc}=T*V_{sdq0} \quad (1)$$

$$V_{labc}=T*V_{ldq0} \quad (2)$$

$$T = \begin{matrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ sinwt & \sin(wt-120) & \sin(wt+120) \\ coswt & \cos(wt-120) & \cos(wt+120) \end{matrix}$$

Shunt controller mitigates current harmonics and other related problems the basic idea of deriving compensating currents.

$$I_{sabs}=I_{sh}+I_{labc}$$

$$I_{sh}=I_{sabc}-I_{labc}$$

Here I_{sabc} is source current; I_{sh} is shunt compensator current, I_{labc} is load current. Compensated current generated is given to Sine PWM scheme to generate pulses for inverter.

FUZZY LOGIC CONTROL

The design of controller is based on dq0 algorithm. First the source and load voltages (three variables) is converted into V_{dq}(two variables) by using park transformation see equation (1, 2). The second order low pass filter (LPF) is used. The sequence of designing controller is as follows.

To maintain the constant dc voltage in active power filters, the fuzzy controller is used. A fuzzy controller arises mainly in situations where the description of the technological process is available only in word form, not in analytical form, it is not possible to identify the parameters of the process with precision, the process is too complex and it is more reasonable to express its description in plain language words, the controlled technological process has a fuzzy character.

SIMULATION OUTPUT

The performance of multilevel UPQC is analyzed in MATLAB software. A source voltage of 440V 50Hz is connected to a load of 80Ω, 0.5mH. A rectifier load of 60Ω, 20mH is switched from 0.3 to 0.4 which acts as a nonlinear load. By sudden switching of inductive load a voltage sag is created.

Table-1. Circuit parameters for overall system.

S. No.	Name	Specifications
1	Source voltage	440V
2	System frequency	50Hz
3	Linear load	80Ω, 0.5mH
4	rectifier load	60Ω, 20mH
5	Filter resistance	20Ω
6	Filter inductance	250mH
7	Switching frequency	1100Hz
8	Injection transformer	1:1
9	Dc link capacitance	1μH
10	Fuzzy controller	Sugeno type

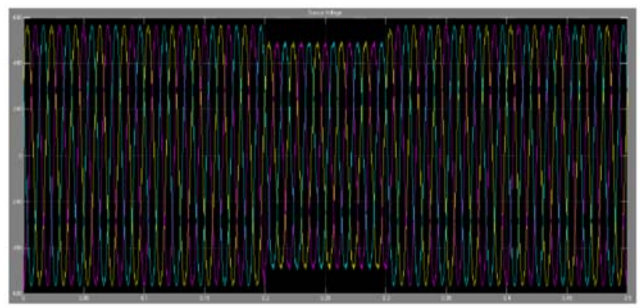

Figure-5. The source voltage before compensation.

Table-2. Comparison of THD value of source voltage before and after compensation.

S. No	Parameter	Before Compensation	After Compensation Using FUZZY Controller
1.	Harmonics (THD)	16.8%	0.36%

Figure-6. The source voltage after compensation.

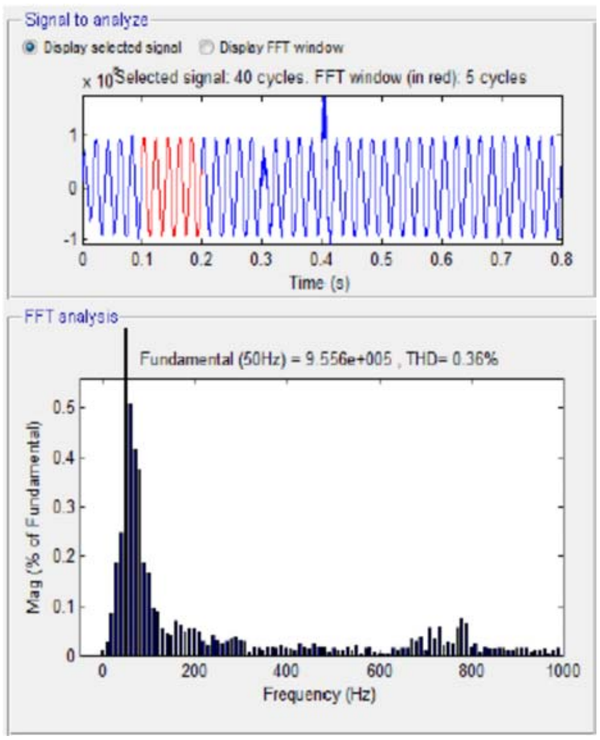

Figure-7. FFT for source voltage after compensation.

CONCLUSIONS

This paper has dealt with the unified power quality conditioner, the aim of which is not only to compensate for current harmonics produced by nonlinear loads but also to eliminate voltage flicker/imbalance appearing at the receiving terminal from the load terminal. The performance of UPQC was tested with fuzzy controller under voltage sag, swell and harmonics are analyzed in MATLAB. From the result THD value is reduced satisfactorily.

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